

CLAIMS

What is claimed is:

1 1. A method for dynamically allocating a buffer, the
2 method comprising:
3 estimating a number of active connections;
4 adjusting a queue threshold for a queue, wherein the
5 queue threshold is adjusted based, at least in
6 part, on the number of active connections;
7 computing a drop probability based, at least in part,
8 on the adjusted threshold and a measured queue
9 size;
10 executing a packet drop routine based upon the drop
11 probability.

1 2. The method of claim 1 wherein the step of estimating a
2 number of active connections further comprises:
3 filtering the estimated number of active connections.

1 3. The method of claim 1 wherein the step of adjusting a
2 queue threshold further comprises:
3 setting the queue threshold ($T(n)$) according to the
4 relation:

5
$$T(n) = \max \left\{ \frac{P}{2\hat{N}(n)-1}, \gamma \hat{N}(n) \right\},$$

6 where P is a bandwidth-delay product, $\hat{N}(n)$ is an
7 estimated number of active connections at
8 measurement time n , and γ is a predetermined

9 parameter that represents a minimum number of
10 packets buffered per connection to avoid a TCP
11 timeout.

1 4. The method of claim 1 wherein the step of computing a
2 drop probability further comprises:
3 sampling the queue size $q(n)$ at a time n ;
4 calculating an error signal $e(n)$, at time n according
5 to the relation $e(n) = q(n) - T(n)$, where $T(n)$ is the
6 queue threshold at time n ; and
7 calculating a drop probability $p_d(n)$, at time n
8 according to the relation

9
$$p_d(n) = \min \left\{ \max \left[p_d(n-1) + \alpha \frac{e(n)}{2T(n)}, 0 \right], \theta \right\}, \text{ where } \alpha \text{ is a}$$

10 control gain parameter and θ is a predetermined
11 upper limit on the drop probability.

1 5. The method of claim 4 wherein the step of calculating
2 an error signal $e(n)$ further comprises:
3 filtering the error signal $e(n)$ according to the
4 relation: $(1-\beta)\hat{e}(n-1) + \beta e(n)$, where β is a filter
5 gain parameter and $\hat{e}(n-1)$ is the filtered error
6 signal at time $n-1$.

1 6. The method of claim 1 wherein the step of executing a
2 packet drop routine further comprises:
3 dropping packets according to a random number generator
4 drop scheme.

- 1 7. The method of claim 1 wherein the step of executing a
2 packet drop routine further comprises:
3 dropping packets according to an inter-drop interval
4 count routine.
- 1 8. An apparatus for dynamically allocating a buffer, the
2 apparatus comprising:
3 an active connection estimator for estimating a number
4 of active connections;
5 a queue threshold adjuster for adjusting a queue
6 threshold for a queue, wherein the queue threshold
7 is adjusted based, at least in part, on the number
8 of active connections;
9 a drop probability calculator for computing a drop
10 probability based, at least in part, on the
11 adjusted threshold and a sampled queue size; and
12 a packet drop module for executing a packet drop
13 routine based upon the drop probability.
- 1 9. The apparatus of claim 8 wherein the active connection
2 estimator further comprises:
3 a filter for filtering the estimated number of active
4 connections.
- 1 10. The apparatus of claim 8 wherein the queue threshold
2 adjuster further comprises:
3 a module for setting the queue threshold ($T(n)$)
4 according to the relation:

5
$$T(n) = \max \left\{ \frac{P}{2\hat{N}(n)-1}, \gamma \hat{N}(n) \right\},$$

6 where P is a bandwidth-delay product, $\hat{N}(n)$ is an
7 estimated number of active connections at
8 measurement time n , and γ is a predetermined
9 parameter that represents a minimum number of
10 packets buffered per connection to avoid a TCP
11 timeout.

1 11. The apparatus of claim 8 wherein the drop probability
2 calculator further comprises:
3 a queue size sampler for sampling the queue size $q(n)$
4 at a time n ;
5 an error signal calculator for calculating an error
6 signal $e(n)$, at time n according to the relation
7 $e(n) = q(n) - T(n)$, where $T(n)$ is the queue threshold
8 at time n ; and
9 a module for calculating a drop probability $p_d(n)$, at
10 time n according to the relation
11
$$p_d(n) = \min \left\{ \max \left[p_d(n-1) + \alpha \frac{e(n)}{2T(n)}, 0 \right], \theta \right\},$$
 where α is a
12 control gain parameter and θ is a predetermined
13 upper limit on the drop probability.

1 12. The apparatus of claim 11 wherein the error signal
2 calculator further comprises:
3 a filter for filtering the error signal $e(n)$ according
4 to the relation: $(1-\beta)\hat{e}(n-1) + \beta e(n)$, where β is a

5 filter gain parameter and $\hat{e}(n-1)$ is the filtered
6 error signal at time $n-1$.

1 13. The apparatus of claim 8 wherein the packet drop module
2 further comprises:
3 a random number generator drop scheme module.

1 14. The apparatus of claim 8 wherein the packet drop module
2 further comprises:
3 an inter-drop interval count routine module.

1 15. An article of manufacture for dynamically allocating a
2 buffer, the article of manufacture comprising:
3 at least one processor readable carrier; and
4 instructions carried on the at least one carrier;
5 wherein the instructions are configured to be readable
6 from the at least one carrier by at least one processor
7 and thereby cause the at least one processor to operate
8 so as to:
9 estimate a number of active connections;
10 adjust a queue threshold for a queue, wherein the queue
11 threshold is adjusted based, at least in part, on
12 the number of active connections;
13 compute a drop probability based, at least in part, on
14 the adjusted threshold and a measured queue size;
15 execute a packet drop routine based upon the drop
16 probability.

1 16. A signal embodied in a carrier wave and representing
2 sequences of instructions which, when executed by at

3 least one processor, cause the at least one processor
4 to dynamically allocate a buffer by performing the
5 steps of:
6 estimating a number of active connections;
7 adjusting a queue threshold for a queue, wherein the
8 queue threshold is adjusted based, at least in
9 part, on the number of active connections;
10 computing a drop probability based, at least in part,
11 on the adjusted threshold and a measured queue
12 size;
13 executing a packet drop routine based upon the drop
14 probability.